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Epidemiology of Concussion in Collegiate and High School Football Players

Kevin M. Guskiewicz,*†‡ PhD, ATC, Nancy L. Weaver,* MPH, Darin A. Padua,* MA, ATC, and William E. Garrett, Jr.,*† MD, PhD

*From the *Sports Medicine Research Laboratory, Department of Exercise and Sport Science, and the †Department of Orthopaedic Surgery, University of North Carolina, Chapel Hill, North Carolina*

ABSTRACT

Despite evolutionary changes in protective equipment, head injury remains common in football. We investigated concussion in football and associated epidemiologic issues such as 1) incidence of injury, 2) common signs and symptoms, and 3) patterns in making return-to-play decisions. We received 242 of 392 surveys (62%) that were sent to high school and collegiate certified athletic trainers at the beginning of three football seasons. Of the 17,549 football players represented, 888 (5.1%) sustained at least one concussion, and 131 (14.7% of the 888) sustained a second injury during the same season. The greatest incidence of concussion was found at the high school (5.6%) and collegiate division III (5.5%) levels, suggesting that there is an association between level of play and the proportion of players injured. Players who sustained one concussion in a season were three times more likely to sustain a second concussion in the same season compared with uninjured players. Contact with artificial turf appears to be associated with a more serious concussion than contact with natural grass. Only 8.9% of all injuries involved loss of consciousness, while 86% involved a headache. Overall, 30.8% of all players sustaining a concussion returned to participation on the same day of injury.

The increased attention that concussion has received in the recent literature may suggest that the incidence of this injury has risen. The importance of sport in present-day American society, and the sensationalized, high-profile cases of concussion reported by the media, has likely contributed to the notion that concussion in sport is highly prevalent. Despite the considerable amount of protective equipment available to athletes today, the head and brain are still susceptible to injury during athletic competition. The most common athletic head injury is concussion, which is considerably less severe than focal injuries such as subdural and epidural hematoma.

A high incidence of concussion in contact sports is well documented in the literature.[5–8,15,26,27,31] Recent statistics estimate that approximately 300,000 sports-related traumatic brain injuries or head injuries occur annually in the United States.[30] The Centers for Disease Control and Prevention reports a high incidence of repeated head injury in several sports and warns that the likelihood of serious sequelae increases with repeated head injury.[11] Although American football is generally recognized as the sport most often associated with concussions, published research reports moderate-to-high incidences of concussion in basketball, softball, soccer, baseball, boxing, rugby, and ice hockey.[20,26]

Earlier studies have reported concussion incidence rates in high school football to be as high as 20% (250,000 players annually)[15] and 15% (200,000 players annually),[31] while annual incidence estimates of 10% were consistently reported in collegiate football during the late 1980s.[3] These figures exceed those reported by the National Athletic Trainers' Association (NATA) high school studies of 1986 to 1988 and 1995 to 1997, which reported incidence rates of only 2.8% and 3.6%, respectively. The researchers concluded that the national figure for concussion in high school football is an estimated 40,000 cases annually.[27] Corresponding data from the collegiate population have ranged between 4.0% and 4.8% annually over the last 6 years.[14]

Deciding when a concussed athlete can safely return to participation after a cerebral concussion is one of the greatest challenges facing athletic trainers and team phy-

‡ Address correspondence and reprint requests to Kevin M. Guskiewicz, PhD, ATC, Director, Sports Medicine Research Laboratory, CB# 8700, University of North Carolina, Chapel Hill, NC 27599-8700.

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sicians. The complexity of the brain and the lack of objective signs and symptoms after injury make the assessment of concussion uniquely challenging. Signs and symptoms that are often present immediately after injury may resolve soon after injury, even when injury to the head may still be life-threatening. Clinicians must often depend on a subjective account of the symptoms reported by an anxious athlete rather than sound, objective data.

Despite there being no universal agreement on the definition of *concussion* and the various levels of severity (grades), the definition cited most frequently is that of a "clinical syndrome characterized by immediate and transient posttraumatic impairment of neural functions, such as alteration of consciousness, disturbance of vision, equilibrium, etc. due to brain stem involvement."[13] The hallmarks of concussion are headache, confusion, and amnesia, and the injury is most often produced by acceleration/deceleration of the freely moving head.[4,28] The concussion grading scale instituted by Cantu[7–10] (see Fig. 1) was used in the current study to define the various grades of concussion.

Athletic trainers and team physicians face a challenging situation when asked to diagnose a head injury and make a decision as to when to return the athlete to play, especially when the athlete participates in a contact sport. Because of the necessarily subjective interpretation of the signs and symptoms associated with concussion, it is often difficult to determine the severity of the initial injury and to make a confident return-to-play decision. Safe guidelines for return-to-play after a concussion have been published by several authors,[2,10,12,18,24] but these guidelines are based on limited scientific data and have been developed largely based on anecdotal clinical evidence. As a result, none of the guidelines have been fully accepted or followed with any consistency by the sports medicine community. Unfortunately, in the case of concussion, clinicians rarely have quantitative information on which to base their decisions.

The purpose of this study was to examine 1) the incidence of concussion in high school and collegiate football; 2) common signs and symptoms, mechanisms of injury, and positions at risk; and 3) return-to-play decisions after concussion. The results of this research will allow clinicians to gain a better understanding of the epidemiology of concussion in sport, and we hope the results will assist them in managing future concussive injuries.

MATERIALS AND METHODS

Sample Selection

A separate random sample of certified athletic trainers was selected from the NATA database for each of the 3 years of the study (1995 to 1997). The population was stratified by employment setting of the athletic trainer (high school and collegiate divisions I, II, and III) and by the geographic district as specified by the NATA (districts 1 to 10). A letter of inquiry was sent to 580 athletic trainers, and a packet with multiple copies of the project report forms (questionnaires) was sent to those people who agreed to participate.

Questionnaires

In the cover letter that accompanied the questionnaires, the athletic trainers were given instructions to complete a concussion report immediately after each concussion sustained by an athlete during the season. This included any player who, based on independent clinical impression, was suspected of having suffered a concussion of any level of severity, and for whom a routine clinical examination for concussion was conducted. Concussion was defined as an acceleration or deceleration injury of the head characterized by immediate and transient posttraumatic impairment of neural functions, such as alteration of consciousness, blurred vision, dizziness, amnesia, or memory impairments. As a component of this report, the athletic trainer or physician graded the injury according to the Cantu[10] concussion classification system presented in Figure 1.

The report also requested information on the circumstances of the injury, such as whether the injury occurred in a game or practice, the position played, how long the athlete remained symptomatic, and how long before the athlete was permitted to return to play (Fig. 1). The concussion summary requested overall school information such as the total number of players at the institution, the total number of injuries and multiple injuries, and who makes the decision for return to play at the school (Fig. 2). The summary was completed by the athletic trainer at the completion of the season.

To assess time at risk for a head injury event, individual exposure was estimated from a stratified subsample of 45 schools. A telephone interview was conducted and supplemented with an additional mail survey to obtain estimates of athlete-exposure for each season for both contact and noncontact player events. This subsample was stratified by level of competition so that athlete-exposure estimates could be applied to all schools in that strata. Information was collected on the total number of football players, the percentage of players that played during games, and the total number of practices and games. Total athlete-exposure per team was calculated as the product of the total number of practices or games and the number of players on the team. Contact athlete-exposure per team was calculated by summing the number of contact practices and the number of games. Contact athlete-exposure estimates were adjusted for the percentage of players who played in each game and any reported absences.

RESULTS

In response to the initial letter, 392 of 580 athletic trainers (68%) agreed to participate. However, only 242 (62%)

Circle One: College Division I, II, III, High School

1. Injury occurred during game or practice?
2. Position playing when injury occurred?
3. Mechanism of injury (contact with: opponent, teammate, ground, surrounding equipment, ... other)
4. What type of playing surface (natural grass, artificial turf)
5. Did athlete return to game/practice on same day?
6. If "yes" to question #5, how long until they returned?
7. If "no" to question #5, how many days until they returned?
8. Number of concussions (excluding present) athlete sustained in last 3 years?___; 1 year? ___; 1 month? ___; 1 week?___
9. Please write the amount of time any of these symptoms were present following the injury: (seconds, minutes, days)

Loss of Consciousness	Dizziness
Confusion	Fatigue
Disorientation	Sleepiness
Memory Loss	Abnormally Irritable
Neck Pain	Disequilibrium
Headache	Blurry vision
Nausea/Vomiting	
Photophobia	Other:

10. According to the following grading scale, what was the severity of injury? (circle grade of injury)

Grade	Loss of Consciousness	Duration of Memory Loss
1	None	< 30 min
2	< 5 min	30 min - 24 hrs
3	≥ 5 min	≥ 24 hrs

Figure 1. Concussion Report

Figure 1. Concussion report.

1. Total number of varsity football players at your institution:
2. Total number of mild head injuries at your institution:
3. Number of players sustaining multiple head injuries:
4. Who clears players for participation following a concussion at your institution?

_____ team physician	_____ neurosurgeon
_____ athletic trainer	_____ parent
_____ team physician & athletic trainer	_____ coach
_____ emergency room physician	_____ other

5. Based on your experience in dealing with head injuries in football, what do you believe are the most likely cause(s) of concussion in football?

_____ equipment fitting incorrectly	_____ lack of prevention and education
_____ unsatisfactory equipment	_____ artificial turf playing surface
_____ poorly skilled players	_____ circumstance - "part of the game"
_____ spearing or lowering head while hitting	
_____ poor sportsmanship or "dirty play"	_____ other (please explain)

Figure 2. Concussion Summary

Figure 2. Concussion summary.

provided complete data and were included in the analyses. Of the 17,549 football players represented at the 242 schools, 888 sustained at least one concussion (5.1%); 131 of these 888 (14.7%) sustained a second injury during the same season. Football players who sustained one concussion were three times more likely to sustain a second concussion during the same season than those players who had not sustained a previous injury.

Incidence

A 4 × 2 chi-square test of independence revealed that incidence of injury per total athletes was significantly

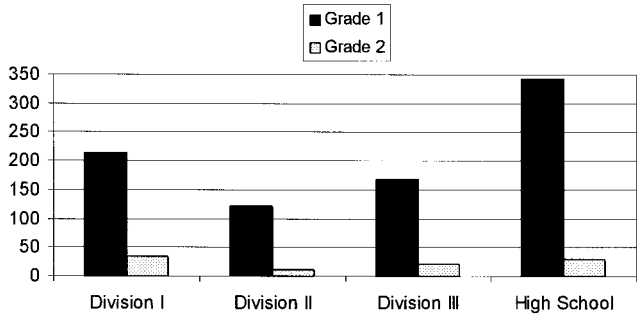

Figure 3. Frequency distribution of injuries by severity and level of competition.

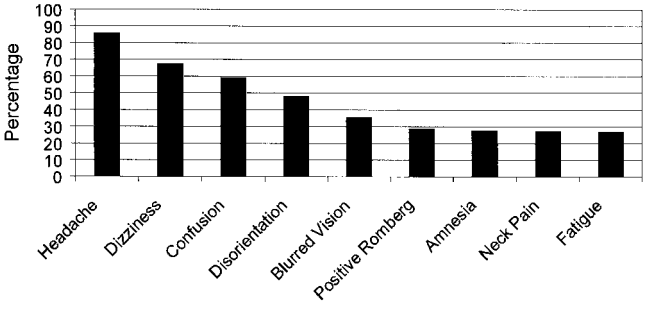

Figure 4. Percentage of total injured players experiencing signs and symptoms associated with head injury.

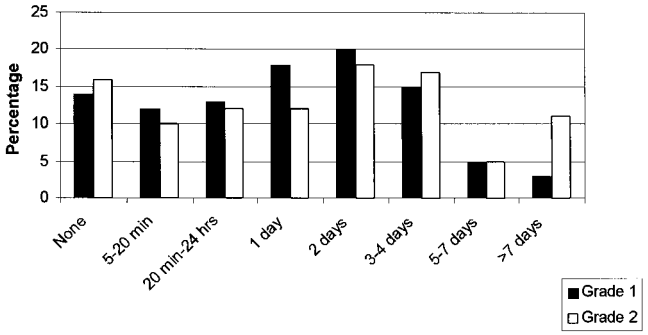

Figure 5. Duration of headache represented by injury grade.

higher at the high school (5.6%) and division III collegiate (5.5%) levels than at division II (4.5%) and division I collegiate (4.4%) levels ($\chi^2(3) = 12.16$, $P < 0.05$). Overall, 5.1% of all football players in the study sustained a concussion during their season. The study also revealed that grade I concussions were the most common type (88.9%), followed by grade II (10.6%) and grade III (0.4%) concussions. (The concussion grading system proposed by Cantu[10] is: grade I, concussion involving temporary alteration in mental status with no loss of consciousness or less than 30 minutes of amnesia, or both; grade II, concussion involving temporary alteration in mental status with increased signs and symptoms usually lasting longer than those of a grade I concussion—however, any loss of consciousness lasts less than 5 minutes and any amnesia lasts between 30 minutes and 24 hours; grade III, concussion that is a more serious injury to the head, usually involving some degree of loss of consciousness, 5 minutes or more, or amnesia, 24 hours or more, or both.) The frequency distribution presented in Figure 3 shows the range of reported incidents for the group of schools.

The overall rate of concussions per 1000 athlete-exposures was 0.70. However, when considering only athlete-exposures involving contact or "live play," the incidence was 1.28 per 1000 athlete-exposure. The injury rates and incidence per 1000 athlete-exposures are presented in Tables 1 and 2. Defensive backs, offensive linemen, and linebackers were the most frequently injured players. However, special teams players and wide receivers were the most likely to sustain a grade II concussion.

The majority of the injuries (59.9%) occurred in game situations as opposed to practice or scrimmage events. The data revealed that the most common mechanism of injury was contact with an opponent (63.6%), followed by contact with a teammate (16.9%), contact with the ground (10.0%), and contact with equipment on the playing field (3.8%). Of the 101 injuries occurring as a result of contact with the ground, 18 (17.8%) occurred on artificial turf and 83 (82.2%) occurred on natural grass. Although less than 10% of all athlete-exposures occurred on artificial turf, four (22%) of the head contacts with artificial turf resulted in a grade II concussion, while seven (9%) of the contacts with natural grass resulted in a grade II concussion. Thus, it would appear that a head contact with artificial turf is disproportionately associated with the occurrence of a concussion and is more likely associated with a more serious concussion than contact with natural grass.

Signs and Symptoms

The most common signs and symptoms reported in the current survey are presented in Figure 4. As expected, a

TABLE 1
Injury Rates by Level of Competition

Level	Schools	Players	Total injuries	Injured players	Player injury rate (%)	Multiple injuries	
						N	(%)
Division I	55	5572	260	246	4.4	24	(9.8)
Division II	28	2497	139	112	4.5	27	(24.0)
Division III	42	3391	204	187	5.5	22	(11.8)
High School	117	6089	400	343	5.6	58	(17.0)
Overall	242	17,549	1003	888	5.1	131	(14.7)

TABLE 2
Athlete-Exposures (A-E) and Rate per 1000 Athletic-Exposures by Level of Competition

Level	Total A-E	Rate/1000 total A-E	Contact A-E	Rate/1000 contact A-E
Division I	533,704	0.49	276,826	0.94
Division II	201,331	0.69	103,673	1.34
Division III	301,980	0.68	155,513	1.31
High school	389,821	1.03	245,033	1.63
	1,426,836	0.70	781,045	1.28

headache was the most commonly reported symptom (86%) among the 1003 total injuries to football players, followed by dizziness (67%, or 672) and confusion (59%, or 592). Of those injuries involving a headache, 28% (241) involved a headache that resolved in less than 24 hours, while 10% (86) involved a headache lasting longer than 5 days. This distribution is similar for grade I and grade II concussions, with the exception of headaches lasting longer than 7 days (Fig. 5).

Fifty-nine percent (592) of the injuries were associated with mental confusion (difficulty with serial sevens and other tests of concentration), and 32% (321) of those injuries involved confusion for more than 10 minutes after the injury. Additionally, 48% (481) of the injuries resulted in disorientation (difficulty with names, places, and times) after their injuries, and 22.6% were disoriented for more than 10 minutes after the injury. Approximately 28.6% (287) of the injuries in the current study revealed a positive Romberg test after injury, and 67.5% (677) of the injuries resulted in dizziness. Blurred vision was also reported after 356 (35.5%) of the injuries. Of those athletes who experienced blurred vision, 37.3% (133) of the cases resolved within 5 minutes and only 17.7% (63) lasted longer than 12 hours.

As evidenced by these findings, a concussion is rarely associated with loss of consciousness (8.9%, or 89) or amnesia (27.7%, or 278). Only 42.7% of grade II concussions were associated with any loss of consciousness, and nearly 80% of these cases resolved in less than 30 seconds (Fig. 6). For those few players who experienced amnesia, 78% of the cases resolved in less than 24 hours, and only 4.6% lasted longer than 5 days. The percentage of grade I and II concussions that led to prolonged loss of consciousness and amnesia is shown in Figures 6 and 7. Grade I and II

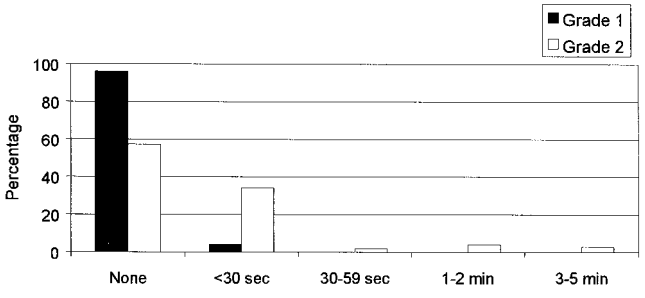

Figure 6. Duration of loss of consciousness represented by injury grade.

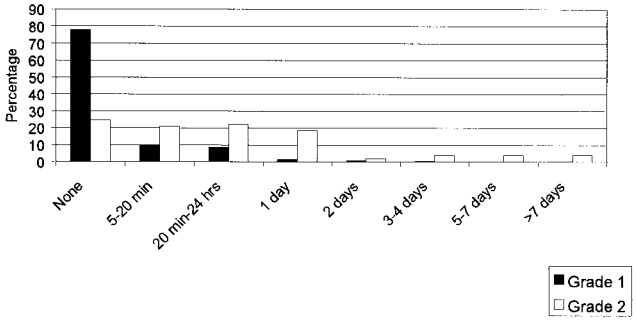

Figure 7. Duration of amnesia represented by injury grade.

concussions are most often differentiated by loss of consciousness or amnesia.[2,10,12,18,24] The majority of grade II injuries reported in the current study involved amnesia in excess of 30 minutes rather than loss of consciousness in excess of 5 minutes. Additionally, the average number of overall symptoms reported in athletes with grade II concussions (7.3) was substantially greater than those for grade I concussions (4.7).

The findings also revealed a consistent association between recurrent injury and the onset of selected symptoms such as amnesia and loss of consciousness. For example, 31% (78) of those players who had sustained a previous concussion within the last year reported experiencing amnesia and 11% (28) reported loss of consciousness with the current injury, compared with 26% (189; amnesia) and 8% (57; loss of consciousness) for those who had not sustained a previous concussion within the last year. Collectively, the total number of reported signs and symptoms associated with recurrent injury was 5.5, compared with only 3.5 for nonrecurrent injury. In summary, the severity of injury appeared to increase with recurrent injury, as the incidence of grade II concussion increased to 13% for those who reported one previous injury in the past year, and 19% for those reporting more than one previous injury within the last year.

Return-to-Play Decisions

Our study revealed that decisions affecting return to play are usually (71% of the time) made by both the team

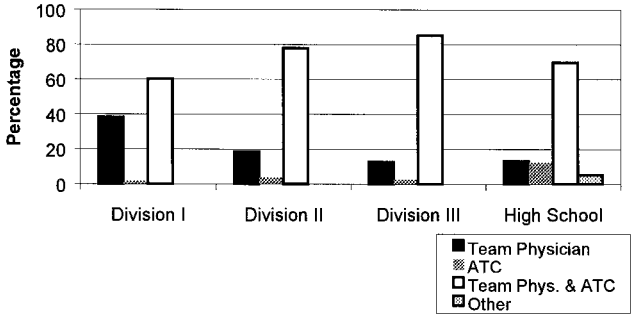

Figure 8. Graph representing which type of clinician makes the decision for when an athlete may return to play.

physician and the athletic trainer. However, at the high school level there is less physician involvement in the decision-making process, and the athletic trainer sometimes (12% of the time) makes decisions independent of the physician (Fig. 8).

Overall, nearly one-third (30.8%) of all football players sustaining a head injury returned to participation on the same day of injury. Of those players returning on the same day, 14.4% had sustained a grade II concussion. On average, the players returning to play on the same day of injury were held out of participation for only 13 minutes. The remaining 69.2% of the injured athletes did not return to participation on the day of injury. Those players sustaining a grade I concussion averaged 4 days after injury before returning to participation, while those sustaining a grade II concussion averaged 8 days after injury before returning to play.

DISCUSSION

One of the difficulties in studying the incidence of concussion is that there is no universally accepted reporting system. Incidence of concussion may be reported as 1) percent of the total injuries, 2) percent of the athletes on the team who will sustain a concussion annually, 3) concussions per 1000 exposures, or 4) concussions per 100,000 impacts. For the purpose of this study, we decided that the percent of athletes on a team who sustained a concussion annually and the number of concussions per 1000 exposures (total and contact) were the most informative. The rate per 1000 total exposures included all athletes on a team who were eligible to participate, and who may or may not have been exposed to contact during a game or practice. The rate per 1000 contact-exposures included athletes who participated in a practice or game in which they were exposed to contact. This rate excluded noncontact practices and players who never entered the game or practice.

Common belief is that the motivation to participate in competitive, aggressive sports has led to bigger, faster, and stronger athletes, and has subsequently increased the velocity of collisions and the severity of head injuries in football. This belief, however, may be fostered by the attention that high-profile professional athletes have received after sustaining multiple head injuries. Although the definition of injury is slightly different in our study, our findings suggest that the incidence of concussion in high school football is not nearly as prevalent as previously reported by Gerberich et al.,[15] who reported in 1983 that 20% of all high school football players sustained a concussion. Although this figure is commonly reported in the literature, it appears to be a gross overestimation of football-related head injury in the late 1990s. A limitation to the study by Gerberich et al. is that it retrospectively surveyed high school players well after the completion of the football season. Our results were collected by certified athletic trainers immediately after the injury occurred. The overall 5.3% rate revealed at the collegiate level is half the 10% rate reported by Barth et al.[4] in 1983, but slightly higher than the annual rate of 4.2% per 100 players reported by Albright et al.[1] in 1985. Additionally, the incidence at the high school and collegiate levels appears to be approximately half the 12% incidence rate reported by the National Football League.[23] The significant association between school level and incidence of injury might be attributed to the increased exposure (athletes playing both offense and defense) often seen at the high school and division III collegiate levels. Other explanations might focus on quality and condition of protective equipment, as well as the skill level of the players.

The decreased incidence of concussion in football that was observed in our study can be attributed to a number of factors, but it is likely due to some combination of factors, such as 1) rule changes that have outlawed spearing and butt blocking, 2) player education about the rule changes and the effects of multiple concussions, 3) implementation of equipment standards, 4) availability of alternative assessment techniques, 5) a marked reduction of physical contact time in practice sessions, and 6) a heightened awareness among clinicians of the dangers involved with returning an athlete to competition while still symptomatic.

When considering the injuries by total athlete-exposures, the high school setting clearly had a higher incidence rate than any of the three collegiate divisions (Table 2). In fact, the high school rate was more than twice that of the division I collegiate rate. This margin narrowed when calculating rates using contact athlete-exposures as opposed to total athlete-exposures. This probably can be attributed to a greater percentage of players on a high school team being exposed to contact as compared with players on a division I college team. We believe that the total contact athlete-exposure rate is a more accurate representation of the time-at-risk involved in football. For example, if a team is practicing in helmets and without pads the day before a game (pregame walk-through), this exposure should not be included in the calculation because, during this time, there is no risk of a player sustaining a head injury. When compared with the 1997 to 1998 NCAA finding of 0.38 injuries per 1000 athlete-exposures, our rate of 0.49 per 1000 total athlete-exposures at the division I level is similar. These NCAA figures include total athlete-exposures. Our rate of 0.94 injuries per 1000 contact-exposures is substantially higher than the total athlete-exposure rates, and our division II (1.34) and division III (1.31) rates are even higher.

These factors can also explain the decline in repeated head injury that was observed in the current study, as 14.7% of the injured players sustained a second injury during the same season. This figure may be alarming, but it is more acceptable than previously reported figures. Albright et al.[1] previously reported that 24% of 100 collegiate football players sustained a recurrent head or neck injury in the same season and that 67% (16) of these players were at risk for sustaining the same injury in some subsequent season. Gerberich et al.[15] concluded that an athlete's risk of suffering a second concussive injury involving "loss of awareness" was four times greater than a player with no such prior experience. Although the definition of injury is slightly different in our study, the risk

factor of nearly three times greater found in our study is fairly consistent with that found by Gerberich et al. This is a figure that should be strongly considered before making any return-to-play decisions. The majority of players in our study were evaluated and released by physicians or athletic trainers (Fig. 8), whereas 41% of the injured athletes in the study by Gerberich et al. were evaluated and released by a coach. Of those injured athletes in the study by Gerberich et al., 69% (401 of 582) returned to participation on the same day, compared with 30.8% in the current study. This factor alone could have predisposed athletes to an increased risk of repeated injury, explaining their higher risk factor for repeated injury. Similarly, 53% of the players in the study by Albright et al. returned to play on the same day.

The distribution of injury grade found in our study is similar to that found in earlier studies. Previous authors have reported that 85% to 90% of all concussions are of a mild grade.[1,6,8,18,27] According to our findings, concussions manifest with varying signs and symptoms, and there appears to be a lack of consistency in how head injuries are managed. Most grading scales are based on loss of consciousness and amnesia. However, the majority of concussions involve neither of these results. Only 8.9% of the 1003 reported injuries involved loss of consciousness, and only 27.7% involved amnesia. Because of this, clinicians are usually forced to make decisions based on grading scales and return-to-play guidelines that do not include the most common signs and symptoms. Research suggests that a change is needed if clinicians are going to begin following any of the guidelines with any consistency.

Most of the current literature on concussion in sport recommends holding athletes from competition for a minimum of 15 to 20 asymptomatic minutes before returning after a grade I concussion and disallowing return to participation on the same day for any athlete who has lost consciousness.[2,8,9,12,19] However, 30.8% of the injured players in the current study returned to competition on the same day, with a mean recovery time of only 13 minutes. Approximately 20% of these players never left the game because their symptoms were not reported or identified until after the practice or game. While these figures may seem alarming, they are more appropriate than previously reported figures indicating that 53% of all athletes with concussions returned to participation on the same day of injury and that 69% of athletes who lost awareness returned to play on the same day of injury.[15] When considering cases where the player was not permitted to return to play on the same day, players averaged only 4.2 days of rest before returning to participation. Many authors have warned of the dangers involved with returning athletes to competition too early, yet according to our findings, these warnings are most often ignored.[7–10,15,18,29] Our findings are consistent with those of Albright et al.,[1] who reported mean recovery times of 4.4 days for athletes with grade I concussions. This represents an average time for return to play of nearly 3 days earlier than most of the recommended guidelines.

All but 14% of the 1003 injuries involved a headache, which means that 86% of the injuries (players) should not have been permitted to return to participation for at least 20 minutes. Many of these headaches lingered for hours or days and should have indicated that the player was not asymptomatic. Any player with a headache that lasted longer than 20 minutes should have been removed from participation for the remainder of the day and observed regularly for postconcussive symptoms. Our results indicate that many players were probably participating while still experiencing a headache. Since 24% of the injured players were still experiencing a headache on postinjury days 3 and 4, there were many players with these lingering symptoms who had not been asymptomatic for longer that 24 hours before returning to participation.

According to our results, clinical practice still contradicts the recommendation of a 1-week rest period after a grade I concussion. The issue in such cases is in trying to determine whether or not the player is truly asymptomatic. Because of the subjective nature of many techniques used for assessment of concussion, several of these players may have been at risk for second-impact syndrome. Athletes who return to participation while still having symptoms from a prior head injury may experience second-impact syndrome, which involves fatal brain swelling after a second concussion. It is thought in these cases that autoregulation of the brain is lost, resulting in catastrophic cerebral edema. Several studies have suggested the use of either neuropsychologic testing[3,17,19–22,29] or postural stability testing[16,17] to add objectivity to the assessment of concussion and decrease the risk of returning an athlete to play while he is still symptomatic.

CONCLUSIONS

Perhaps the most important finding in this study is that high school and collegiate football players who sustain a concussion are nearly three times more likely to sustain a second concussion in the same season than those players who have not sustained a previous injury. This may be related to the fact that players are often returned to play prematurely, as nearly one-third of football players return to play on the same day, after an average of only 13 minutes of rest. The remaining two-thirds of the players return an average of only 4 days and 8 days of rest for grades I and II concussions, respectively. The findings of this study confirm the belief that clinicians do not follow the recommended guidelines for return to play, all of which call for at least a 15- to 20-minute clearing period on the sideline, followed by a week of rest and monitoring of symptoms for those athletes who fail to clear quickly. For the most part, athletic trainers and team physicians collaborate to make decisions as to when an athlete should be allowed to return to play; however, at the high school level the decisions are often made solely by the athletic trainer.

The question that needs to be answered by clinicians is whether or not they can determine with certainty that a player is asymptomatic. Unfortunately, few clinicians are currently using assessment techniques such as neuropsychologic testing and postural stability testing, which have been shown to be useful in identifying lingering signs and symptoms such as concentration deficits, blurred vision,

photophobia, amnesia, dizziness, and balance deficits. The current grading scales are based primarily on amnesia and loss of consciousness, both of which only occasionally accompany sports-related concussion. Because the consequences of making a poor decision as to when an athlete may return to play after concussion could be severe, researchers and clinicians need to develop safe and practical guidelines based on a multitude of objective variables. Epidemiologic investigation should be coupled with basic science research to help us gain a better understanding of the best way to develop the guidelines for managing concussion in sport.

ACKNOWLEDGMENTS

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